Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER	153793
UNCLASSIFIED		

TITLE

MACGRID, A PROGRAM FOR GENERATING A MESH FOR MAVART

System Number:

Patron Number:

Requester:

Notes:

UNLIMITED DISTRIBUTION

National Defence
Research and
Development Branch

Défense nationale
Bureau de recherche
et développement

DREA CR/95/433

MacGrid, A PROGRAM FOR
GENERATING A MESH FOR MAVART

by

G.W. McMahon — B. L. Fanning

FANTECH CONSULTING SERVICE
67 Spikenard Street
Dartmouth, Nova Scotia, Canada
B2W 3B6

CONTRACTOR REPORT

Prepared for

**Defence
Research
Establishment
Atlantic**

**Centre de
Recherches pour la
Défense
Atlantique**

Canada

THIS IS AN UNEDITED REPORT ON SCIENTIFIC OR TECHNICAL WORK
CONTRACTED BY THE DEFENCE RESEARCH ESTABLISHMENT ATLANTIC OF
THE RESEARCH AND DEVELOPMENT BRANCH OF THE DEPARTMENT OF
NATIONAL DEFENCE, CANADA.

THE CONTENTS OF THE REPORT ARE THE RESPONSIBILITY OF THE
CONTRACTOR, AND DO NOT NECESSARILY REFLECT THE OFFICIAL POLICIES
OF THE DEPARTMENT OF NATIONAL DEFENCE.

PLEASE DIRECT ENQUIRIES TO:

THE CHIEF,
DEFENCE RESEARCH ESTABLISHMENT ATLANTIC,
P.O. BOX 1012,
DARTMOUTH, NOVA SCOTIA, CANADA
B2Y 3Z7

<u>UNLIMITED DISTRIBUTION</u>

National Defence
Research and
Development Branch

Défense nationale
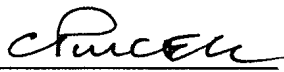Bureau de recherche
et développement

DREA CR/95/433

MacGrid, A PROGRAM FOR GENERATING A MESH FOR MAVART

by
G.W. McMahon — B. L. Fanning

FANTECH CONSULTING SERVICE
67 Spikenard Street
Dartmouth, Nova Scotia, Canada
B2W 3B6

Scientific Authority

Christopher J. Purcell

March 1995

W7707-4-3046/01-HAL
Contract Number

CONTRACTOR REPORT

Prepared for

**Defence
Research
Establishment
Atlantic**

**Centre de
Recherches pour la
Défense
Atlantique**

Canada

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual).

This report describes work done to produce a prototype computer program called MacGRID, whose purpose is to generate finite element models for the analysis code · MAVART. MacGRID, as its name suggests, is designed to run on an Apple Macintosh computer, and all of the standard menus found in a Macintosh application are supported, in addition to the special menus required to generate a finite element model. The application has two windows, one shows the model in graphical form, where the model can be created and manipulated with a mouse driven interface. The other is a text window, which allows the model data file to be viewed and edited using standard Macintosh editing techniques. Deficiencies in the present version of the code are noted, and suggestions for future development work are detailed.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

finite element analysis
model generation
Apple Macintosh Computer
MAVART
transducer
design

Ce rapport décrit les travaux effectués pour produire un prototype de programme d'ordinateur appelé MacGRID, qui sert à générer des modèles à éléments finis pour le code d'analyse MAVART. Comme son nom l'indique, MacGRID est conçu pour tourner sur micro-ordinateur Macintosh d'Apple et peut utiliser tous les menus qui se retrouvent normalement dans une application Macintosh, en plus des menus spéciaux nécessaires pour générer un modèle à éléments finis. L'application comporte deux fenêtres, la première montrant le modèle sous forme graphique et permettant la création et la manipulation du modèle à l'aide d'une interface à souris. La seconde fenêtre est une zone de texte servant à afficher et à modifier le fichier de données du modèle selon les techniques normales d'édition Macintosh. Les lacunes de la présente version du code sont indiquées, et des suggestions sont décrites en détail en vue de futurs travaux de développement.

MacGRID, A Program For Generating A Mesh For MAVART

Contract No. W7707-4-3046/01-HAL
Final Report (Phase Ia)

1. Introduction

MAVART is a two-dimensional, dynamic finite-element computer program developed for DREA under research contracts to Canadian industry. It has been used primarily for analysis of axisymmetric electroacoustic transducers, and the name is an acronym for the code's function, that is, a **M**odel to **A**nalyze the **V**ibrations and **A**coustic **R**adiation of **T**ransducers. The complete MAVART package comprises: (a) **GRID** [1], a program to generate the finite element mesh and the corresponding input data file for MAVART, (b) **MOD**, a program to modify the input data file, (c) **MATER**, a program for generating material properties data for input to MAVART, (d) **MAVART** itself, which sets up the mathematical model and solves it, and (e) **GRAF**, a post-processing graphics program to display the results of the MAVART analysis. All of these programs were written in FORTRAN to run on a VAX computer, but some require other hardware and/or software packages; e.g., GRID requires a digitizing table.

The Macintosh computer is an ideal platform to perform all of the above functions, using only the devices that are normally available on any Macintosh. In an earlier contract, FanTech Consulting Service re-engineered the **MAVART** code to operate on a Macintosh computer without the use of scratch files, eliminating many time-consuming disk reads and writes.

FanTech has now developed a working version of **GRID** for the Macintosh (MacGRID), the subject of this contract. MacGRID follows the Macintosh Human Interface Guidelines as much as possible, so, with the interface presented to the user, mesh generation is a simple, almost intuitive procedure. In this version of MacGRID, there are a number of limitations that will be eliminated in future work.

This Interim Report will present a brief overview of the work done in Phase Ia of this contract and will present recommendations for tasks to be performed in Phase Ib. The results of problem testing will be discussed.

2. Phase Ia Overview

The Macintosh user interface for MacGrid has been set up, using the AppMaker™ application, which is supported by Language Systems Fortran operating in the Macintosh Programmer's Workshop (MPW) programming environment. All of the standard Menus found in a Macintosh application are included, plus some special Menus required by MacGrid. Other parts of the user interface are Dialogs, a graphics Window, a text Window, and Palettes for selecting any action required by the user to set up a MAVART input data file. An existing MAVART data file can be read and displayed in the text Window; It can then be edited, saved, and/or printed. The Graphics Window can also be printed.

Other features and the limitations of this present version of MacGRID are found in *User's Manual for MacGRID* which accompanies this report and is one of the deliverables of this contract.

1

3. Recommendations for Future Work: Phase Ib

In order to make MacGRID a more versatile grid generating program for MAVART, the following additions and enhancements are recommended:

* Redesign palettes and insert appropriate palette titles.

* Enable MacGRID to accommodate other screen sizes.

* Add a "**Delete...**" menu item to both the **Nodes** and **Elements** menus. Selecting this item will invoke a dialog box allowing the user to list specific nodes or elements to be deleted. This will be useful when the elements are very small and/or the node distribution is very dense, making selection with the mouse difficult. There is also a situation where the user can inadvertently create an areal element with no area, and thus cannot delete the element with the mouse.

* Create a small window outside the drawing region to display the cursor coordinates during node action.

* Add a dialog that will be invoked when "**?...**" is chosen in the polang palette. The user can then type in specific polang values.

* Under the **Elements** menu, insert an item that will give the user the option of retaining all nodes when deleting elements.

* Implement the "**Fixity...**" button in the node palette. When invoked the user will be presented with a dialog asking for the type of fixity and the value. The user will then be instructed to click on the appropriate nodes.

* Implement the "**Change Type**" in the node palette. The user will be instructed to choose a type from the palette and click on the nodes to be changed.

* Implement the "**Choose Z&R**" in the node palette to allow the user to set specific coordinates for a node.

* If the "**Reorder**" item in the "**Nodes**" menu is deemed useful, it will be implemented, allowing the user to resequence the nodes.

* Write code to automatically generate FTOS elements when contiguous fluid and solid elements are created.

* Generate error checking code for ensuring that nodes are chosen in the proper order when creating elements.

* Modify the code and the dialog for creating nodes on a radius so that there is more flexibility in specifying origin, angles, and radius, etc.

2

- Generate code to add some of the functions available in **MOD** [2,3]. These functions will be available as menu items and will facilitate the editing of MAVART data files. Some that might be included, are:

  - Change Z (R) — The user chooses nodes and a new Z (R) value.
  - Divide Z (R) equally — The user chooses nodes to be evenly spaced along Z (R).
  - Add to Z (R) — The user chooses nodes and a value to be added to Z (R).
  - Scale Z (R) — The user chooses nodes and a factor by which the Z (R) nodal coordinate is to be multiplied.
  - Straight Z (R) — The user chooses nodes for movement in Z (R) to a straight line.
  - Delete all Fluid Nodes — Removes the fluid nodes from the model.
  - Delete all Fluid Nodes excluding FTOS elements — Removes the fluid nodes from the model except those in FTOS elements.
  - Equal angle division — The user types in the coordinates of an origin and a list of nodes for equal angle division.

- Write code so that changes in the Text Window are reflected in the Graphics Window.

- Remove present 32k limit on the size that the Text Window can handle.

- Review the use of color in the Graphics Window and generate the code to make desired changes and additions.

- Review axis labeling in the Graphics Window and generate the code to make appropriate changes.

All of these recommendations will be discussed in detail with the Scientific Authority. Further recommendation for changes and additions will no doubt be made during the use of this early version of MacGRID. All of the approved recommendations will become part of the statement of work for Phase Ib.

4. Testing MacGRID.

MacGRID will read in most existing MAVART data files and display the model in the graphics window. All of the implemented procedures appear to work correctly. However, if very large data files are read, the text window becomes corrupted beyond the 32k point.

A number of new models have been generated, edited, saved and printed without apparent error. Because of the many different sequences that may be used in generating a model, and because of the interdependency of the various procedures, it is most likely that conflicts and errors will occasionally occur. Attempts will be made to correct these when reported.

Most of the data files in the Examples Manual [4] can be read into MacGRID and displayed on both the graphics window and the text window. Problem D19 can be read in and displayed correctly in the graphics window, but the text window does not present the data properly beyond the 32k point. MacGRID can be used to edit these data files (except D19) within the limitations imposed by this version.

3

5. Phase II of Contract.

As stated in the proposal for this contract, the aim is to develop a complete MAVART package including MAVART, GRID, GRAF, MATER and MOD. With the completion of Phase Ib, the items remaining to be implemented are GRAF and MATER. As mentioned in **3.** above, some desirable features of MOD could be incorporated in MacGRID, eliminating MOD as a separate application. The effort required to produce a Macintosh version of GRAF (MacGRAF) will be comparable to that expended in MacGRID. The effort involved in producing a Macintosh version of MATER will be considerably less.

Some enhancements to MAVART may be desirable. For example, PROFIL, the bandwith reducer used for MAVART, could be incorporated into MAVART. This could prove useful when analyzing a model having a large number of poorly ordered nodes by significantly reducing the storage (RAM) requirements. This would be especially true for some Macintosh machines with limited RAM.

Some thought could be given to the possibility of eliminating the need of double precision variables in the MAVART solver. If such were possible and were to be implemented, the amount of RAM needed for a given problem would be reduced very significantly.

6. References

[1] **Bruce A. Armstrong**, GRID, *A Fortran Program for Using a Digitizing Table to Enter a Finite Grid for MAVART.* DREA Technical Memorandum 84/Y, November 1984.

[2] **B. L. Fanning**, *Changes to GRID and MOD, Fortran Programs for Modifying MAVART Data Files*, DREA Note SP/86/2.

[3] **Bruce A. Armstrong,** A User's Manual for MOD, a Fortran Program for Modifying Finite Elements Grids for MAVART, DREA/RN/SP/84/3, May 1984.

[4] **G. McMahon and E. Skiba**, *Examples Manual for Program MAVART*, DREA Technical Memorandum 90/204, August 1990.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.) Fantech Consulting Service 67 Spikenard St. Dartmouth, NS, B2W 3B6	2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable). UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title).

MacGRID, A Program For Generating a Mesh for MAVART

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

G. W. McMahon and B. L. Fanning

5. DATE OF PUBLICATION (month and year of publication of in document) 31 MARCH 1995	6a. NO OF PAGES (total containing information Include Annexes, Appendices, etc). 4	6b. NO. OF REFS (total cited document) 4

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered).

CONTRACTOR REPORT

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address).

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant). 1AU-13	9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written). W7707-4-3046/01-HAL
10a.ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document). DREA CR/95/433	10b.OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor).

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected).